

Creek, near Crater Lake, Klamath County, Ore.

*Thomomys monticola helleri* Elliot: Gold Beach, mouth of Rogue River, Curry County, Ore.

SUBSPECIES OF THE *THOMOMYS UMBRINUS* GROUP NOT PREVIOUSLY RECOGNIZED AS SUCH

*Thomomys umbrinus quercinus* Burt and Campbell: Peña Blanca Spring, altitude 4,500 feet, near Mexican boundary, north of Monument 128, Pajarito Mountains, Santa Cruz County, Ariz.

*Thomomys umbrinus proximus* Burt and Campbell: Old Parker Ranch (Pickett's Ranch on U. S. Geological Survey topographic map, Patagonia Quadrangle, edition of August 1905), altitude 4,800 feet, west slope of Santa Rita Mountains, Pima County, Ariz.

SUBSPECIES OF *THOMOMYS BOTTAE* HITHERTO TREATED AS DISTINCT SPECIES

*Thomomys bottae magdalenae* Nelson and Goldman: Magdalena Island, Lower California, Mexico.

*Thomomys bottae martirensis* Allen: San Pedro Martir Mountains (8,200 feet), Lower California, Mexico.

Additional specimens of *Thomomys bottae collinus* Goldman, from Fly Park (9,000 feet), Chiricahua Mountains, Ariz., indicate that the characters ascribed to *Thomomys umbrinus chiricahuae* Nelson and Goldman, from Pinery Canyon (7,500 feet), Chiricahua Mountains, Ariz., are within the range of individual variation in that subspecies. The name *Thomomys umbrinus chiricahuae* should, therefore, be placed in the synonymy of *Thomomys bottae collinus*.

ICHTHYOLOGY.—*The osteology and relationships of the bathypelagic fishes of the genus Bathylagus Günther with notes on the systematic position of Leuroglossus stilbius Gilbert and Therobromus callorhinus Lucas.*<sup>1</sup> WILBERT MCLEOD CHAPMAN, California Academy of Sciences. (Communicated by LEONARD P. SCHULTZ.)

This report describes the bony structures and the gross visceral anatomy of the genus *Bathylagus*, discusses its relationships, and defines the family Bathylagidae. A brief account is given of the anatomy of *Leuroglossus stilbius*, and reasons why it should be placed in the Bathylagidae rather than the Argentinidae are listed. *Therobromus callorhinus*, known only from bones found in the stomachs of the fur seals of the North Pacific, is identified as a species of *Bathylagus*.

The genus *Bathylagus* comprises at present 16 species of fishes, 8 of which have been described in the past 12 years. Representatives occur on both sides of the North and South Atlantic Oceans, in the Antarctic, off the west coast of North America from southern Mexico to the Bering Sea, and in the Okhotsk Sea. They typically inhabit deeper water layers outside the continental shelf (Norman, 1930; Parr, 1931 and 1937; Beebe, 1933; Chapman, 1939 and 1940), al-

though *B. argyrogastrus* has been taken toward the surface layers (Norman, 1930).

*Bathylagus* was originally placed by Günther (1878) in the Salmonidae. Regan (1909 and 1914) considered it to be a member of the Argentinidae, and Norman (1930), Parr (1931), Beebe (1933), and others have followed him. Jordan and Evermann (1896) placed it in the Microstomidae, as did Barnard (1925) and others. In recent years it has been placed both in the Argentinidae and Microstomidae by the compilers of the Pisces section of the Zoological Record. Gill (1884), with his usual keen insight, erected for the genus the family Bathylagidae by name only, but Goode and Bean (1895) gave a diagnosis of the family. Gill's classification has been followed by Jordan (1923), Jordan, Evermann, and Clark (1930), Fowler (1936) Parr (1937), and most recently by Berg (1940).

This study is based upon dissections of *Bathylagus pacificus* Gilbert taken by the International Fisheries Commission in the Gulf of Alaska and off the coast of British

<sup>1</sup> Received February 11, 1943.

Columbia. The illustrations are based on an adult female, with well-developed eggs, taken off the west coast of the Queen Charlotte Islands, IFC station 321c (Thompson and Van Cleve, 1936). Diagnoses have been made on specimens of *B. alascanus* Chapman and *Leuroglossus stilbius* Gilbert. Unless otherwise mentioned, references to the anatomy of *Argentina*, *Microstoma*, and *Macropinna* are based upon dissections by the writer.

It is a pleasure to acknowledge the kindness of H. A. Dunlop, director of investigations, International Fisheries Commission, in allowing me to work on their specimens of *Bathylagus* and *Macropinna*; Dr. George S. Myers, Stanford University, in providing me with a specimen of *Leuroglossus*; and Dr. Leonard P. Schultz, curator of fishes, U. S. National Museum, for the loan of specimens of *Argentina* and *Microstoma*.

#### ANTORBITAL PORTION OF CRANIUM

Ethmoid cartilage (Figs. 1-3) restricted in extent by size of ethmoid and prefrontal ossifications; extending anteriorly as broad, flat plate between dorsal and ventral ethmoid bones; thickest between prefrontals where it rises to frontals and shows between them; pierced on inner edge of prefrontals by foramina of olfactory nerves; extending unbroken under frontals to sphenotics, thus separating orbitosphenoid and alisphenoids from frontals; ventral surface flat, with palatine synchondrized along entire edge anterior to prefrontals as in *Macropinna* (Chapman, 1942b); running posteriorly for short distance along parasphenoid.

Mesethmoid (Figs. 1, 3) consisting of a nearly circular, flat plate, which forms greater part of rostral plate, and a strong buttress, which rises from dorsal surface of this plate to meet frontals.

Ventral ethmoid (Fig. 2) a thin circular plate like mesethmoid above it; shallowly concave on ventral side; perhaps homologous with similar bone in certain osmerids (Chapman, 1941b).

Frontals (Figs. 1-3) everywhere separate, with cartilage exposed between them posteriorly, anteriorly, and between orbits; lying over only a portion of edges of sphenotics and supraoccipital posteriorly; sloping evenly and gently downward from supraoccipital to mes-

ethmoid. Each bone bearing on its lateral edge a high and prominent trough in which frontal extension of lateral line system lies and to which broad, thin supraocular and postfrontal of circumorbital series are attached membranously; these structures probably special ossifications of sensory system, but indistinguishably fuse with frontals; higher anteriorly than width of frontals between them and responsible for concavity of interocular region; formed from extremely thin bone and quite separate from broad supraorbitals.

Prefrontals (Figs. 1-3) thin, broad ossifications of nearly circular shape in lateral ethmoid cartilage, with very thin lateral edges.

Parasphenoid (Figs. 2, 3) long, slender, and straight, extending from ventral ethmoid to basioccipital; concave on ventral surface under ethmoid, with broad posterior shaft of vomer lying in cavity; heaviest and widest where it reaches prootics; posterior extension of bone thin and lying flatly in shallow concavity of basioccipital. No true myodome. Parasphenoid flatly attached to prootics and heavy cartilage between those bones so ocular muscles attach in shallow concavity formed by short wings of parasphenoid and bulky ventral edges of prootics.

Vomer (Figs. 1-3) heavy and large, projecting anteriorly beyond ethmoid structures; on anterior edge bearing 30 to 32 conical teeth, which are set in sockets in bone, project slightly anteriorly as well as ventrally, and form entire dentition of upper jaw; a notch in bone at lateral corner of dentigerous area into which anterior end of palatine fits; long, broad, median shaft projects back in concavity of ventral ethmoid to end on parasphenoid.

#### POSTORBITAL PORTION OF CRANIUM

Cartilage of postorbital portion of cranium everywhere restricted in extent (Figs. 1-3); reduced to narrow bands, which disappear between supraoccipital and epiotics; expanded between supraoccipital and sphenotics, but these areas covered by parietals; somewhat expanded between epiotics and exoccipitals; greatest expansion between basioccipital and prootics, but considerable part of this covered by parasphenoid; sockets of hyomandibula lines with cartilage.

Dorsal surface of postorbital portion of

cranium with no prominent ridges or depressions, sloping gently and evenly from parietals to posterior edge of pterotics without definite temporal fossae, and sloping between conical tips of epiotics and supraoccipital down to foramen magnum.

Supraoccipital (Figs. 1, 2) broad and shield-shaped, forming prominent portion of dorsal surface of cranium; anterolateral edges of bones covered by parietals; lateral portion of anterior edge covered by frontals, but median portion exposed; bluntly pointed posterior end sloping downward, but broadly separated from foramen magnum by epiotics and exoccipitals; short, sharp vane of bone projecting from midline, on which originate two thin but tough muscles, which extend back between myomeres and along distal ends of interneurals to origin of dorsal fin.

Thin, scalelike parietals (Figs. 1, 3) widely separated by supraoccipital, partially covering sphenotics and supraoccipital and completely covering cartilage between those bones.

Epiotics (Figs. 1, 3) prominent, conical bones meeting broadly behind supraoccipitals, receiving ligament from dorsal fork of posttemporal on blunt tip of bone, and each with deep concavity on posterior surface.

Sphenotics (Figs. 1-3) prominent bones with considerable dorsal, lateral, and anterior surface. Socket of hyomandibular resting not so much on sphenotic as upon cartilage between that bone and prootic.

Pterotics (Figs. 1-3) with socket of hyomandibular angling across entire ventral surface of each bone. From dorsal surface a long, bulky column of cartilage, which joins ventral and dorsal surfaces internally, can be seen.

Alisphenoids (Figs. 2, 3) large bones providing anterolateral protection for brain; separated from prootics, sphenotics, and orbitosphenoid by slender bands of cartilage, and everywhere separate ventrally.

Orbitosphenoids (Figs. 2, 3) meeting mesially but not completely fused; from ventral edge a very thin strand of ossification extends into interorbital membrane; olfactory nerves emerging between bones anteriorly.

Ventral side of cranium marked by triangular expansion of basioccipital and prootics, in which the large otoliths lie. Otolith capsules not projecting ventrally as much as in *Macropinna* or the osmerids.

Prootics (Figs. 2, 3) largest bones of ventral surface of cranium, marked by otolith expansions and by small posterior foramen of trigemino-facial complex; these two foramina separated by thin, strongly ossified bridge, which forms sharp ridge setting off anterior from ventral surface of bone; bones separated ventrally by broad, thick band of cartilage; anterior end of this cartilage much thickened and slightly concave, with shallow concavity between it and parasphenoid. Posterior eye muscles inserted in this area.

Each exoccipital (Figs. 1-3) strongly concave on ventral side with two foramina in posterior part of concavity, the posterior of which is much the larger; posterior projection of bone lying along condyle of basioccipital, sending process dorsally, separated from similar process of other exoccipital by narrow band of cartilage; these two processes form sides and roof of foramen magnum but do not form part of condyle and do not articulate with any process of first vertebra; concavity of posterior surface of epiotic continued on posterior surface of exoccipital.

Constricted posterior end of basioccipital (Figs. 1-3), which forms occipital condyle, heavily ossified and bearing ridges of denser ossification ventrally and laterally; ventral surface of bone shallowly concave anteriorly.

Opisthotic (not shown in Fig. 3) tiny and oblong; in some specimens lying entirely on exoccipital midway between foramen of vagus nerve and lateral edge of bone, and in others lying more laterally and partially resting on cartilage between exoccipital and pterotic; curving around posterior edge of exoccipital and thus with a small posterior surface which is not visible dorsally; receiving ligament from ventral fork of posttemporal.

#### SPECIAL OSSIFICATIONS OF SENSORY SYSTEM

All bones associated with extension of lateral line system over head thin and weak, most with no tubes developed for protection of nerves, but acting merely as supports. Nasal thin, slender, semitubular, and almost flattened; lying directly over nasal capsule; by no means so big or broad in my specimens as in Beebe's (1933, fig. 37). Six bones of circumorbital series as shown by Beebe, except that in my specimens postorbital considerably larger than supra-orbital. It is interesting to note the turn evolu-



tion has taken in the big-eyed *Bathylagus*, whose eyes are placed laterally and strongly protected dorsally by the expanded supra-orbital and postorbital; whereas in the big-eyed *Opisthoproctus* (Trewevas, 1933) and *Macropinna* (Chapman, 1942b), which have the eyes dorsally directed, these bones are absent and the eyes are protected by enormously expanded suborbitals, bones that are weakly developed in *Bathylagus*.

A semitubular bone, attached to sphenotic directly behind eye, bridging gap for nerve

ankylosed to that bone. Ossified tube for nerve present on mandible, securely ankylosed to both dentary and angular.

#### UPPER JAW

Premaxillary and maxillary thin and delicate, neither bearing teeth nor having gape edge thickened for that purpose (Fig. 4); upper jaw loosely bound to cranium by delicate membranes only, neither bone equipped with anterior condyle for attachment to cranium; anterior end of premaxillary lying in groove be-

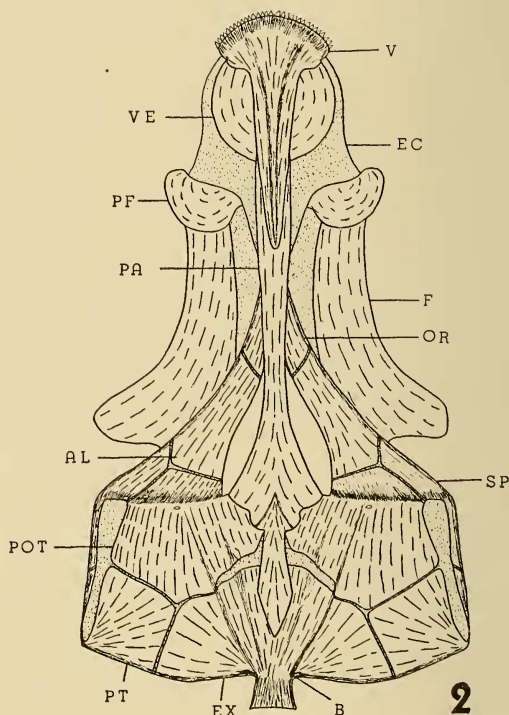
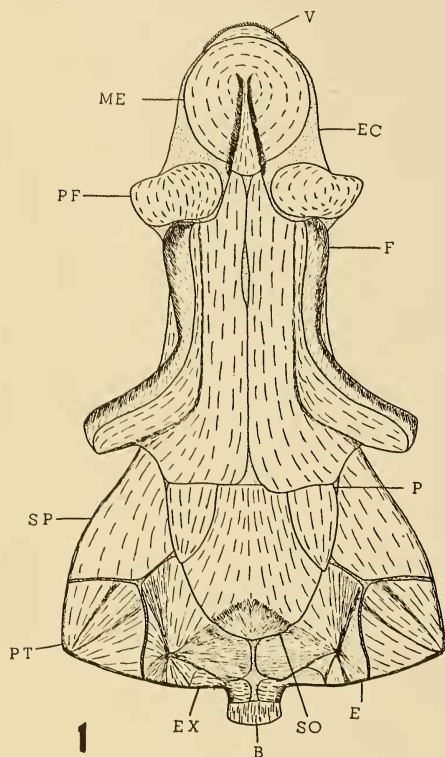


Fig. 1.—Dorsal view of the cranium of *Bathylagus pacificus*. Fig. 2.—ventral view of the cranium of the same.  $\times 32$ .

between sphenotic and preopercle. Nerve encased in tube on dorsal arm of preopercle, but on ventral arm this tube opens ventrally to become trough. A short tube protects nerve on lateral face of opercle, projecting downward from condyle. Protection for nerve over sphenotic and pterotic irregular, not tubular and exceedingly flimsy. Lightly ossified tissue lending some support to nerve between cranium and supraclithrum. Nerve running ventrally on supraclithrum in trough of thin bone securely

tween anterior end of mesethmoid and vomer, not meeting premaxillary of other side; bound rather loosely to premaxillary but not to palatine. No supramaxillary found in any specimen (such a bone is shown by Beebe, 1933, in fig. 36, but not in fig. 39, and is not mentioned by him in the text).

#### MANDIBLE

Mandible (Fig. 4) consisting of dentary, articular, angular, sesamoid articular, Meckel's



cartilage, and a superficial ossified tube for mandibular branch of lateral line system. Dentary forming greater part of mandible, so thin that sesamoid articular can be seen through it in stained specimens; overlying considerable portion of articular; bearing 82 teeth in specimen drawn, which are conical, small, and closely pressed together in a single series.

interior shaft of articular to a similar but slenderer shaft on inner side of dentary; not thick, but broad posteriorly. Sesamoid articular thin and of irregular shape, with longest axis anterior-posterior, and area about one-third that shown for articular (Fig. 4); lying principally on dorsal edge of Meckel's cartilage, but extending also onto articular and dentary. Thin

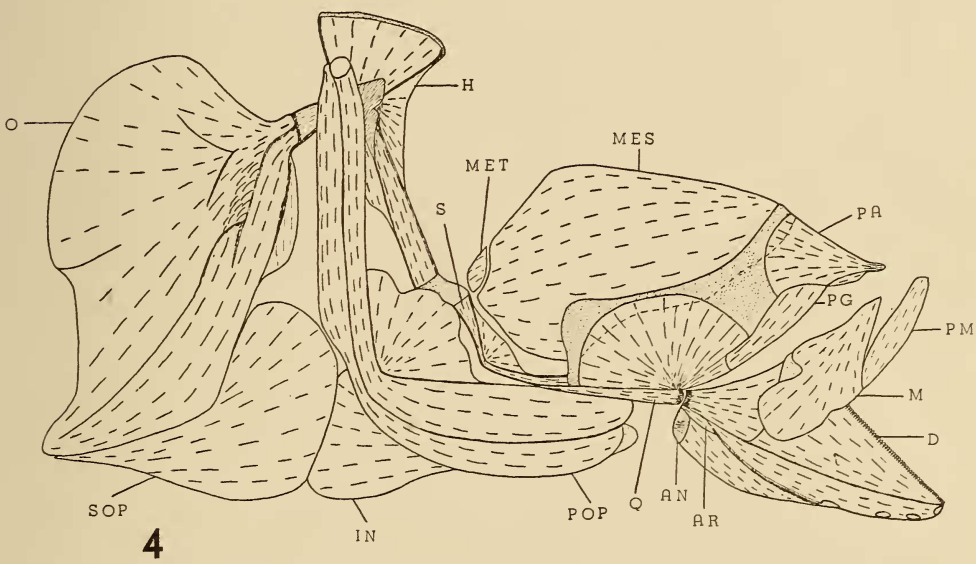
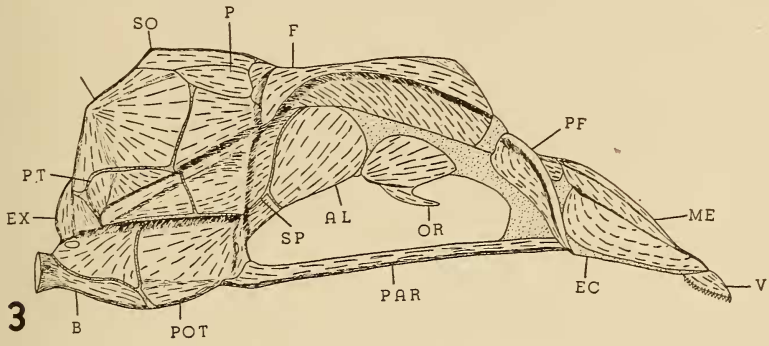


Fig. 3.—Lateral view of the cranium of the *Bathylagus pacificus*. Fig. 4.—Lateral view of the suspensorium of the same.  $\times 3.2$ .

Angular small but heavily ossified, receiving broad ligament from interopercle. Articular triangular with heavily ossified socket of articulation at apex, with strong, thick shaft of bone extending forward from socket on mesial side, presumably ossification of posterior third of Meckel's cartilage.

Meckel's cartilage about one-third length of mandible, extending from above-mentioned

ossified tube for mandibular branch of lateral line system on external side of dentary and articular, obviously a special ossification of sensory system but indistinguishably fused to the mandibular bones. Sensory canal communicates with exterior by means of four pores in the bone.

PALATINE ARCH

Palatine (Fig. 4) securely joined along entire

dorsal edge to ethmoid cartilage as in *Macropinna*, thus forming firm support between bones of oral cavity and cranium; band of cartilage behind palatine also participating in this junction. Anterior end of palatine more heavily ossified than rest of bone and inserted in cavity between vomer and ethmoid cartilage; no teeth on palatine of specimens examined, but since vomerine dentition extends posteriorly under anterior tip of palatine, the latter appears to bear a few teeth until a complete dissection is made.

Pterygoid (Fig. 4) simple, well-ossified bone joining palatine and quadrate together strongly, overlapping both bones laterally as well as mesially.

Quadrate (Fig. 4) has form of nearly half a circle, with small but heavily ossified condyle; slender process projecting posteriorly along preopercle and symplectic, thus binding palatine and hyoid arches together and binding both to preopercle.

Broad band of cartilage around quadrate forms broad patch between quadrate and palatine and extends around end of latter to synchondrize with ethmoid cartilage. This does not extend posteriorly along symplectic. Simple, thin membrane between symplectic and mesopterygoid.

Mesopterygoid (Fig. 4) broad, thin and very similar to same structure in *Macropinna* and *Opisthoproctus* (Trewavas, 1933); ventral edge lies under quadrate and palatine (dotted line in Fig. 4), and entirely mesial to cartilage of this region, to which it is tightly bound. Bone appears to be an ossification of membranes of roof of mouth and therefore not properly considered with cartilage bones of palatine arch. Metapterygoid either absent or represented by small bit of bone behind mesopterygoid (Fig. 4). Of same structure as mesopterygoid and separated from that bone by thin membrane only; doubtfully homologous with metapterygoid of other isospondylous fishes.

#### HYOID ARCH

Hyomandibular (Fig. 4) articulating along full lateral surface of pterotic and sphenotic as in *Macropinna* and *Opisthoproctus* (Trewavas, 1933). Articulation anteriorly on cartilage between sphenotic and prootic. Opercular condyle nearly as long as articular head although much slenderer, leaving considerable open

space between opercle and preopercle. High, thin wing of bone extending from lateral side of hyomandibular at level of opercular condyle attached by membranes to preopercle and adjacent bone of circumorbital series. Truncus hyoido-mandibularis facialis nerve pierces bone in large foramen which extends nearly straight ventrally from inner to outer side of bone to emerge on thin wing of bone on posterior side of shaft of hyomandibular. Wing of thin bone present in anterior angle between articular head and ventral shank of the bone.

Column of cartilage between hyomandibular and symplectic (Fig. 4) with characteristic anterior twist so that symplectic does not continue in direct line with ventral shaft of hyomandibular. A similar condition is found in *Opisthoproctus* (Trewavas, 1933). Interhyal articulates with mesial side of this cartilage.

Symplectic (Fig. 4) a semicylindrical shaft bent forward near its middle to form an approximately right angle with wing of thin bone in angle. Symplectic extends to, but not beyond, cartilage around posterior edge of quadrate.

Hyoid apparatus (Fig. 5) consisting of interhyal, epihyal, ceratohyal, two hypohyals, a glossohyal (Fig. 6, not Fig. 5), and two broad and thin branchiostegal rays, except for latter all bones sturdy and thick, being heaviest bones of skull. Branchiostegal rays inserted entirely on cartilage surrounding ventral side of epihyal. Ceratohyal constricted in its middle and with numerous irregular ridges of denser ossification there. Posterior two-thirds of glossohyal (Fig. 6) ossified; anterior broader third cartilaginous. Dental cement bone covering most of dorsal surface of cartilage and extending back onto ossified portion of element. It bears no teeth, but since it presents a hardened, fairly sharp, and slightly upturned anterior edge, it conceivably may be of considerable aid in handling live food.

#### OPERCULAR APPARATUS

All four opercular elements present (Fig. 4); all thin, flexible bones. A few rays of denser ossification radiate outward from socket of articulation of opercle. Short tube protecting portion of lateral line system running downward from articulation along exterior face of that bone. Subopercle extends into space between opercle and preopercle but does not fill it. Por-

tion of posterior edge of bone covered by opercle. Long, slender interopercle nearly covered by horizontal arm of preopercle; its anterior end attached by a broad ligament to angular and posterior end securely attached by membranes to subopercle. Broad wing of thin bone present in angle of preopercle. Sensory canal tubular on vertical arm of preopercle and with numerous small openings to surface dorsally, but ventral edge of canal separated from main

bone on horizontal arm and tube becomes a trough. An interspace present between vertical arm and lower end of hyomandibular, and between horizontal arm and symplectic, both closed only by thin membranes.

# GILL ARCHES

First three basibranchials (Fig. 6) ossified but cartilaginous on both ends; ossified portions of all three round in cross section. Last

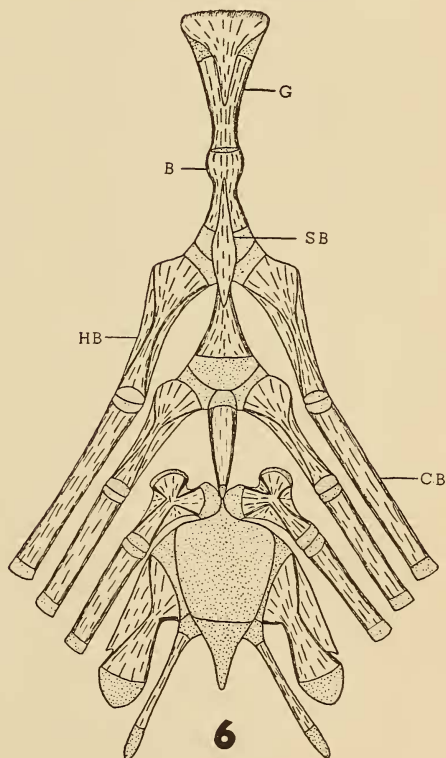
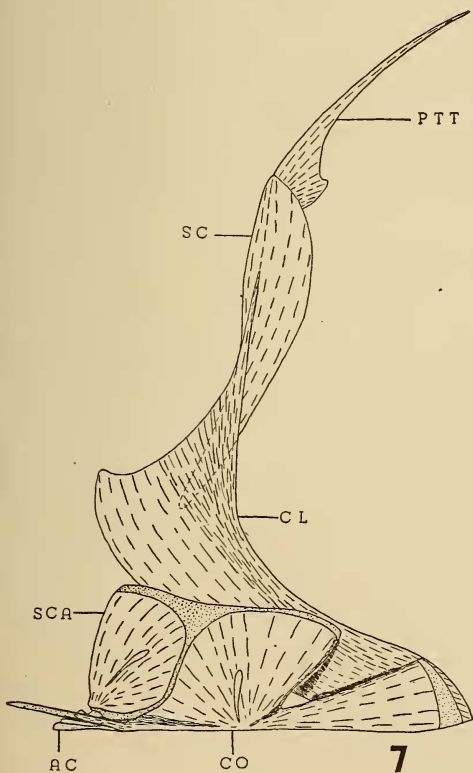
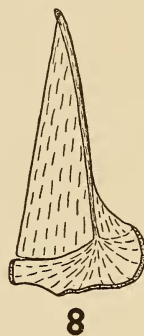
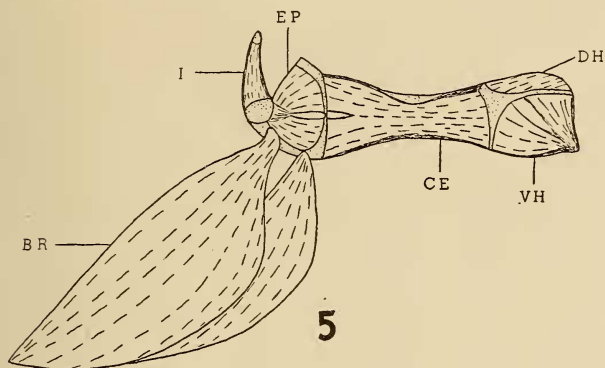


Fig. 5.—Lateral view of the hyoid apparatus of the *Bathylagus pacificus*. Fig. 6.—Dorsal view of the ventral half of the gill arches of the same. Fig. 7.—Mesial view of the shoulder girdle of the same. Fig. 8.—Dorsal view of the right pelvic bone of the same. All figures are  $\times 3.2$ .



two basibranchials entirely cartilaginous, presenting a flat dorsal surface but with a constriction marking off two on ventral surface. Dental cement bone joining dorsal surfaces of first and second basibranchials and covering a portion of cartilage between them, probably homologous with larger element in same position in osmerid fishes and *Plecoglossus* (Chapman, 1941a). It bears no teeth.

Hypobranchials (Fig. 6) present on first three arches. Those of third arch with anterior process, which projects ventrally to a slight degree. One can visualize the possible origin of the peculiar third hypobranchial of the Osmeridae and *Plecoglossidae* from this structure. If the posterior process (the main portion of the bone) diminished to nothing, until the ceratobranchial touched the fourth basibranchial, and the anterior process elongated and turned more ventrally until it surrounded the ventral aorta the osmerid third hypobranchial would be achieved.

Ceratobranchials (Fig. 6) on all five arches. First three bent dorsally a little at middle. Small muscle that originates on the hypobranchial inserted on slight projection from ventral side of bone at this bend. Fourth ceratobranchial broad, somewhat thickened and constricted anteriorly to an hour-glass shape. Wide shelf of thin bone present in lateral (or anterior) angle on which broad muscle extending dorsally to expanded fourth suprabranchial originates. Fifth ceratobranchial a slender, weak bone, which bears no teeth.

First three epibranchials ossified, and each bears, near mesial end of dorsal side, a cartilage-capped process that articulates with similar processes from, respectively, the second, third, and fourth suprabranchials. This process largest on third epibranchial. Fourth epibranchial entirely cartilaginous and reduced to band of cartilage attached firmly to ventral edge of expanded fourth suprabranchial.

No suprabranchial found on first arch. Second small and flat with dorsoanterior process reaching to first epibranchial and a smaller dorsoposterior process articulating with third suprabranchial. Third suprabranchial more elongate because of long anterior process. Fourth suprabranchial broadly expanded and little resembling others; turned nearly at right angles to plane of other suprabranchials and

extending dorsally until band of cartilage around its dorsal end articulates with cranium. Broad muscle inserted over entire posterior surface of bone extending directly ventrally to fourth ceratobranchial. This muscle must be of considerable importance in the movements of the gill arches. An identical apparatus is found in *Microstoma* and *Macropinna* and probably *Opisthoproctus* (Trewevas, 1933).

#### SHOULDER GIRDLE

All elements of shoulder girdle weak, thin, and more or less pliable (Fig. 7). Posttemporal consists mostly of long, thin dorsal fork, curving backward somewhat, in manner not possible to show in Fig. 7, to resemble a sickle, lying over dorsal corner of epiotic and separated from posttemporal of opposite side only by tendon from supraoccipital. Strongly attached to epiotic by a ligament, which extends forward from its attachment to epiotic to lie flatly on under side of posttemporal so that latter can be drawn backward some little bit but can not be pushed forward at all. It would thus aid somewhat in dissipating the thrust of the pectoral fin to the cranium. Ventral fork of posttemporal short, blunt, and attached to opisthotic by a fairly strong ligament.

Supracleithrum thin, pliable bone bearing lateral line nerve on outer side in trough. Whether this trough is an integral part of the bone or a special ossification of the sensory canal that has become securely fused to the supraclithrum could not be determined. Cleithrum largest bone of girdle, ending dorsally in long, sharp spike. Completely ligamentous first rib attached to this and supraclithrum, not only to bind girdle securely to axial skeleton but also to bind the two bones together. Lateral-anterior face of bone broadened for insertion of sternohyoideus muscle on outer surface, and muscles of fin on inner surface.

Primary shoulder girdle attached flatly by cartilage to inner surface of cleithrum and curving away at angle of not more than 45°. Both scapula and coracoid fairly large, but neither very strongly ossified. Scapular foramen a mere elongated slit and entirely contained within bone. Coracoid with similar foramen of about same size and shape and another, much smaller, opening near ventral end of that. Anterior process of coracoid strong and

broad with V-shaped interosseous space between it and main part of bone. Posterior process elongate and slender, projecting posteriorly well beyond actinosts. Posterior two-thirds of this spike cartilaginous and pliable. In one specimen this elongate projection was either absent or unwittingly lost in dissection. Four actinosts tiny, placed closely together and all based on cartilage between scapula and coracoid. No mesocoracoid or postcleithra.

#### PELVIC GIRDLE

Support of small pelvic fins slight and weak (Fig. 8); consisting of a single, elongate triangular bone on either side which tapers to a point anteriorly. Except for posterior side of triangle bone thin and pliable in spite of border of heavier ossification along outer side. Posterior edge thickened and cartilaginous for support of fin rays. Mesially two prongs, ventral and dorsal, project from thickened posterior end to meet similar prongs of opposite pelvic bone. Dorsal prong broad, completely ossified, except for thin band of cartilage around its edge of junction, and arching dorsomesially. Two ventral prongs, slenderer and bluntly pointed, meet mesially just under skin. For mesial third of their length both are entirely cartilaginous. Two pelvic bones rather weakly joined together.

#### AXIAL SKELETON

Forty-two complete vertebrae plus single upturned terminal centrum present. First semblance of haemal spine, a short, sharp stub to which rib of each side attaches, occurs on sixteenth vertebra. Spine of seventeenth vertebra slender and about one-half as long as longest haemal spine. That of eighteenth vertebra longer yet and that of nineteenth of full length. Sixteenth vertebra thus first caudal vertebra, but anus placed back much farther, under twenty-sixth vertebra. Rib of sixteenth vertebra of full length. Ribs also on seventeenth, eighteenth, and nineteenth vertebrae. Each somewhat shorter than one preceding until that of nineteenth only about half length of that of sixteenth vertebra. These last three ribs very loosely attached by membranes to their respective haemal spines. All ribs are exceedingly slender and pliable and seem to give slight protection to abdominal cavity.

Both epineurals and epipleurals present; all scarcely thicker than muscle fibers. Last epipleural noted posteriorly was on rib of sixteenth vertebra and last epineural posteriorly was on twentieth neural spine, but because of their delicacy it cannot be securely stated that they do not occur farther back on the caudal vertebrae.

Centra all completely ossified, elongate, slender, hour-glass shape. Parapophyses of pre-caudal vertebrae, while broad, quite thin. Two of each centrum not joined ventrally. A considerable interspace between those of succeeding centra. Ribs flattened and slightly broadened on proximal ends and lying flat on external side of parapophyses.

Neural spines, especially of first 13 vertebrae, exceedingly slender and thin except for their broadened proximal ends where they attach to centra. Those of each side of a single centrum do not touch, even at their filamentous distal ends, on first 13 vertebrae. Those of fourteenth and all succeeding vertebrae join and become firmly ankylosed directly above spinal cord and thus form a single spine. These spines considerably heavier and stronger than those on anterior vertebrae. About eight to ten times as much of spinal cord exposed between succeeding neural spines as covered by bases of slender spines.

Nine interneurals between cranium and first baseost of dorsal fin. Each of these except ninth inserted between distal tips of succeeding neural spines. Ninth lies in same interspace as eighth, although with normal spacing between them. It appears to have been crowded out of its normal place by the enlarged, bifid, first baseost of the dorsal fin. Each interneural capped on either end with cartilage, heavier than neural spine, well ossified, and approximately round in cross section. Between all interneurals is developed an apparatus that the writer has not seen so well developed in dissection of any other fish. This consists of a rather strong ligament running from the distal end of each interneural nearly ventrally to a little below the middle of the next interneural posteriorly. This is not a single ligament but is made up of several fibers, some of which are inserted on the cartilage cap, some on the bone proper. This set of ligamentous connections between the interneurals unites them all into a

single apparatus starting with the broad ligament between the supraoccipital and first interneural, and attached lightly to the first baseost of the dorsal fin. It has the effect of dispersing any strain coming to the anterior member (the cranium) throughout the entire apparatus.

No ribs, epineurals, or epipleurals on first vertebra, and no interneural between first neural spine and cranium. In place of a rib a strong ligament of similar diameter as a normal rib strongly attached to shoulder girdle (as noted above). In my specimens ribs of second vertebra fully developed and as large as any others.

Eight baseosts for dorsal fin, each supporting a fin ray. First longest and largest, bifid ventrally but reaching only to, and not straddling, neural spine of tenth vertebra. Eighth very small and consists of little more than distal knob for insertion of fin ray. Other baseosts all similar, differing only in becoming progressively shorter from second to seventh. Each bone ends distally in heavy knob and tapers ventrally to slender proximal end. All latter widely separate. Baseosts several times heavier than corresponding neural spines. Distally each baseost connected with next one posteriorly by small hour-glass-shaped bone. Each of these bones cupped on each end and each cup lined with cartilage. Dorsal line of baseosts thus solid and strong for support of fin, but flexible by reason of 14 small ball and socket joints.

Eighteen baseosts for anal fin presenting flexible, but entire, line distally for support of fin rays by reason of small hour-glass-shaped ossicles between thickened heads of baseosts, as in dorsal fin. Baseosts decrease gradually in length posteriorly until eighteenth is little more than one-third length of first. All slenderer than corresponding supports of dorsal fin. Little if any support gained from slender haemal spines. First baseost bears on its anterior edge, near distal end, a cartilage capped knob to which are attached by tendon two muscles which extend along ventral line of abdomen to shoulder girdle and help to anchor pelvic girdle in place.

Support of caudal fin rather weakly developed. Small dorsal rays of fin extend anteriorly to level of neural spine of thirty-sixth vertebra. Neural spines of last six vertebrae extend to proximal ends of fin rays, very

slender, and in no way differentiated for support of rays. Condition essentially the same ventrally except that haemal spine of forty-second vertebra somewhat broadened and thickened distally and covered by cap of cartilage over distal edge of hypural plate to actively support fin. Haemal spine of forty-first and fortieth vertebrae also slightly thickened but lend little support to fin.

None of elements of hypural plate fused together and considerable interosseous spaces left between some. Terminal centrum cone shaped and with pointed end turned upward slightly. Slender, cartilaginous urostyle extends dorso-posteriorly into fin rays as in *Novumbra* (Chapman, 1934) and other fishes. Neural spine of terminal centrum, while thin and weak, widely broadened to fill most of space between last neural spines and urostyle, and covers base of latter. Further dorsally a slender rod of bone lies along upper side of urostyle until latter reaches fin rays. This bone tipped with cartilage distally. Lower side of urostyle sheathed with still another thin bone on which upper three hypurals inserted. Lower four hypurals based on ventral side of terminal centrum. All hypurals capped with cartilage distally and, in addition, with a continuous band of cartilage from urostyle to haemal spine of forty-second vertebra over which proximal ends of fin rays actually ride. Flanges on neural and haemal spines of last several vertebrae shown by Beebe (1933, fig. 41) not present in my specimens.

#### VISCERA

Stomach J-shaped, large, with very thick walls and covered externally with black pigment. Internally closely packed, deep, thin folds almost fill lumen of stomach so that little space left inside in proportion to size of organ. It is possible, however, that this is capable of considerable expansion, for the stomach of the only specimen cut into was completely empty except for minute flaky particles that could not be identified.

Five pyloric caeca, three moderately good sized, one smaller, and one very short and small. One of larger ones and medium sized one come off ventral side of pyloric region together, former curving upward and posteriorly along left side of pyloric end of stomach, latter curving to right and running anteriorly along py-



loric region. Other three caeca come off right side of pyloric region and lie between it and intestine. Anterior one only a short bud; other two projecting posteriorly, with largest one curving across ventral side of pyloric end of stomach to extend along left side.

Somewhat in advance of pyloric caeca intestine flexes to right and continues straight posteriorly to anus. Anterior two-thirds of intestine rather thin-walled and flabby; lined internally with irregular small folds, which do not project far into lumen and which block off wall into shallow crypts of irregular shape. About two-thirds of remaining third of intestine turgid and nearly cylindrical. It contains a typical spiral valve almost identical in size and shape with that shown by Kendall and Crawford (1922) for *Argentina*. Organ obviously functional and well developed, not vestigial remnant occasionally found in salmon. Spirals made up of spongy, thickened walls with contours as evident in external view as in *Squalus*. Remainder of alimentary tract pigmented, although not so heavily as stomach, and may be termed the rectum, although little different in circumference from spiral valve section.

Specimen examined a female with well-developed eggs. Both ovaries full of eggs and of about same size, with right extending only little more posteriorly than left. Ovaries lay along dorsal side of stomach and nearly enclose intestine clear to rectum. Two sizes of eggs present: larger size about 0.5 millimeter in diameter. Number of large eggs not counted with accuracy but estimated that two ovaries together contained less than 3,000.

Only right lobe of liver present in three specimens examined, but this well developed and covering large part of left surface of stomach. Spherical, translucent gall bladder exactly as found in *Macropinna* (Chapman, 1942b). In one specimen liver notched on ventral edge and gall bladder fitting snugly in this notch over bend of intestine. In another specimen liver covers gall bladder from external view but a bulge in its surface shows presence of bladder in same location.

Kidney similar to that of *Macropinna*; light gray in color and shot through with small black specks. No indication of double structure.

No air bladder (as in *Macropinna*).

#### SYSTEMATIC POSITION OF LEUROGLOSSUS GILBERT

Dr. George S. Myers has kindly provided me with one of Gilbert's specimens of *Leuroglossus stilbius*. The specimen is small and soft, and the bones are so lightly ossified that they did not take up the stain readily. Therefore it was not possible to give a complete account of its osteology. Definitely there are no mesocoracoids, no postcleithra, and no air bladder. There are only two branchiostegal rays. All osteological characters that can be clearly defined, such as the ethmoid and suspensorium areas (with the mouth parts and vomer), are as in *Bathylagus*. However, the liver is somewhat bilobed; there is a distinct kink in the intestine behind the greater omentum and the intestine is longer than in *Bathylagus*; there are 12 pyloric caeca all in a straight line and the whole of the alimentary tract is enfolded dorsally and ventrally in a double organ which I believe is the greatly enlarged (in proportion to the size of the fish) male sex organs. Because of the above noted characters of the viscera the generic rank should be retained until more complete study indicates otherwise. *Leuroglossus* should be removed from the Argentinidae and placed in the Bathylagidae.

The counts and measurements (in millimeters) of my specimen (*Albatross* station 2904: 1889, southern California) are as follows: anal, 11; dorsal, 10; pectorals, 9; ventrals, 9; caudal, 48. Snout to base of caudal, 48; snout to origin of dorsal,  $27\frac{1}{4}$ ; snout to insertion of ventrals, 29; snout to anal, 38; snout to adipose,  $40\frac{1}{2}$ ; length of head, 17; diameter of eye, 6; depth at pectoral insertion,  $8\frac{1}{2}$ ; length of caudal peduncle, 6; and length of snout,  $4\frac{1}{4}$  mm.

#### SYSTEMATIC POSITION OF THEROBROMUS LUCAS

Lucas (1899) described the species *Therobromus callorhinus* from bones found abundantly in the stomachs of fur seals in Bering Sea. No intact specimens were available to him, and the species has never been taken alive, nor have specimens been recorded since his original description. He says of it:

"an undescribed isospondylous fish related to the Argentinidae." It has since been referred to the Osmeridae by Jordan, Evermann, and Clark (1930) and Hubbs (1925), but a study of the osteology of the osmerid fishes (Chapman, 1941b) showed that the species was not closely related to those fishes and could not be placed in that family.

Lucas says of the fish: "The species may be diagnosed as follows: Chondrocranium well developed; superior maxillary edentulous; pointed teeth on vomer and anterior portion of palatines; lower jaw very deep; pointed teeth on dentary; articular well developed. Vertebral formula 26 precaudals, 22 caudals, plus 1 hypural; last 4 precaudals with short, wide hypapophyses: other hypapophyses long; neural spines of first 22 vertebrae double, remainder confluent; an epineural present and confluent with basal part of neurapophysis on many of the anterior vertebrae; short transverse processes, directed downward from lower part of anterior vertebrae. Vertebrae simple; anterior but very little shorter than the posterior; centra not sculptured, but bearing many fine longitudinal ridges." The short description was accompanied by a plate of 19 drawings of bones.

The description, except for the number of vertebrae, could have been as correctly drawn from the specimens of *Bathylagus* used as the basis for the present report. The drawings likewise are accurate representations of *Bathylagus*. The chief differences between Lucas's drawings and those in the present report are the result of his specimen being partially digested, and the resemblances are so striking that no detailed description is necessary. The frontals in his specimen, for instance, are gone; part of the opercle is digested away; and part of the hypural plate is gone. The vertebral count given in the description of *Therobromus* by Lucas will aid in identifying his species when specimens of *Bathylagus* from the Bering Sea are available for dissection. Probably his fish was *B. pacificus* or *B. alascanus*.

The discovery that the fur seal feeds extensively on fishes of the genus *Bathylagus* is interesting because this genus in the

North Pacific is typically bathypelagic in habitat, indicating that the fur seal feeds at greater depths than is generally recognized. It may be noted that the chief feeding grounds of the fur seal while on the rookeries both on the Pribilof and Komandorskie Islands is outside the 100-fathom contour (Townsend, 1899).

#### SYSTEMATIC POSITION OF BATHYLAGUS

The affinities of the Bathylagidae are not so close to the salmonoid fishes as is generally supposed. Together with the Argentinidae, Microstomidae, Macropinnidae, Opisthoproctidae, Winteriidae, Xenophthalmichthyidae, and, probably, certain other deep sea fishes, they form a natural group that may be designated as a suborder in the Isospondyli, the Opisthoproctoidei, erected by Berg (1937) for the Opisthoproctidae alone.

Of the fishes with which *Bathylagus* has been associated in the past it resembles *Argentina* least. *Argentina* (Chapman, 1942a) has a well-developed mesocoracoid; a single row of about 30 teeth on the palatine; several heavy recurved teeth on the tongue; small teeth on the fifth ceratobranchial and fourth suprabranchial; the air bladder is large and well developed; there are seven branchiostegal rays; well-developed postcleithra (there are four in my specimen, although Kendall and Crawford (1922) say no "postclavicular" processes are found); the myodome is well developed and opens posteriorly on the basioccipital; the parietals are broadly joined on the midline, nearly occluding the supraoccipital from dorsal view, and form bony bridges across the temporal fossae laterally; and the supraoccipital is broadly separate from the frontals. In view of these differences, and others, *Bathylagus* can not be placed in the Argentinidae.

There are stronger resemblances with *Microstoma*, but that genus has an especially large and prominent air bladder; four branchiostegal rays; well-developed postcleithra; the parietals meet broadly on the midline of the skull; and there are numerous differences in the proportions and arrangements of the bones of the skull, in particular



the special ossifications of the sensory system and the bones of the ethmoid region. For these and other reasons *Bathylagus* can not be considered to be a member of the Microstomidae.

*Bathylagus* is the representative of a separate family, Bathylagidae (Gill, 1884), to which also belongs *Leuroglossus* (Gilbert, 1890). *Bathymacrops* (Gilchrist, 1922), which Jordan (1923) has placed in the Bathylagidae, should be placed in the Microstomidae as a synonym of *Nansenia*.

SYNOPSIS OF THE FAMILY BATHYLAGIDAE

Opisthoproctoid fishes with adipose fin and enlarged but laterally directed eyes. Supraorbital bones strongly developed and suborbital bones weakly developed. Mouth small. No teeth on tongue, gill arches, premaxillary or maxillary. Teeth on palatine absent or few. Small conical teeth on the vomer and dentary. Mesopterygoid much enlarged but not toothed. Metapterygoid minute, if present. Frontals paired. Both mesethmoid and ventral ethmoid present. Small suprabasal present on basibranchials. Parietals small and widely separated by supraoccipital, which reaches frontals. No definite temporal fossae. No myodome. No mesocoracoid. No postcleithra. Two (as far as known) branchiostegal rays. Gill membranes broadly united. Pectoral and ventral fins small and placed near the ventral outline. Pseudobranchiae well developed. Pyloric caeca few (9 to 12 in *Leuroglossus*, 5 or 6 in *Bathylagus*). Peritoneum and stomach jet black. Air bladder completely absent. Stomach with prominent leaflike projections internally. Intestine short, with well-developed spiral valve.

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## ABBREVIATIONS USED ON FIGURES

AC = actinost	E = epiotic	ME = mesethmoid	PT = pterotic
AL = alisphenoid	EC = ethmoid cartilage	MES = mesopterygoid	PTT = posttemporal
AN = angular	EP = epihyal	MET = metapterygoid	Q = quadrate
AR = articular	EX = exoccipital	O = opercle	S = symplectic
B = basioccipital	F = frontal	OR = orbitosphenoid	SB = suprabasal
BB = basibranchial	FM = foramen magnum	P = parietal	SC = supracleithrum
BR = branchiostegal ray	G = glossohyal	PA = palatine	SCA = scapula
CB = ceratobranchial	H = hyomandibular	PAR = parasphenoid	SO = supraoccipital
CE = ceratohyal	HB = hypobranchial	PF = prefrontal	SOP = subopercle
CL = cleithrum	I = interhyal	PG = pterygoid	SP = sphenotic
CO = coracoid	IN = interopercle	PM = premaxillary	V = vomer
D = dentary	M = maxillary	POP = preopercle	VE = ventral ethmoid
DH = dorsal hypohyal		POT = prootic	VH = ventral hypohyal